Chapter 2
DEP Stormwater Management Objectives

Four Stormwater Management Objectives:

- Effective Pollutant Removal
- Cooling
- Channel Protection
- Flood Control

2.1 Problems with Traditional BMP Designs

The Department recognizes that some of the traditional stormwater management standards that have been applied in the past to new developments, are either inadequate or may actually be causing problems in the resources to which they drain. The current philosophy is now built around insuring that stormwater management systems for new developments meet the following four objectives: effective pollutant removal, cooling, channel protection, and flood control. In some instances, the latter three objectives are not necessary, such as for direct discharges to lakes, large rivers or some tidal waters; but stormwater management systems should always provide effective pollutant removal. These objectives will be discussed in detail later but first we will look at some of the shortcomings of traditional stormwater management.

Failure to Protect Stream Channel Integrity

As urban areas develop, the volume of runoff rises because of the increase in impervious area. Also, natural drainage patterns are modified, with runoff channeled into road drainage ditches or storm sewers. These modifications increase the velocity of runoff and decrease the travel time required for runoff to reach the receiving surface water. Stormwater rises much more rapidly to peak discharges that are much higher, often resulting in higher flood stages in the receiving water.

Figure 2-1 shows typical pre- and post- development hydrographs. The hydrographs represent the flow rates of stormwater discharges from the site before and after development. The area below each hydrograph represents the volume of runoff for that particular storm event. As shown on the figure, both the peak discharge flow rate and volume are lower under natural pre-development conditions since

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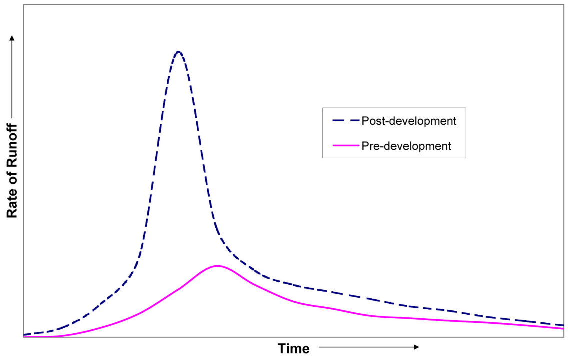


Figure 2-1. Pre and Post Development Hydrographs

stormwater is able to slowly seep into the ground with slow release to surface water over a period of days. The post-development peak flow rate and volume are much higher since the water turns into surface runoff and hits the receiving water body all at once.

As a result, the stream channel experiences higher flows more frequently and for longer durations. These higher velocity flows cause stream banks to erode and the channel to widen. Eroded sediment is deposited in slower down-stream reaches. The frequency of these channel disturbances limits the quality of the habitat in the stream channel, especially for organisms with longer life cycles.

Peak flow attenuation, where stormwater is detained so that the post-developed peak flow does not exceed pre-developed peak flow, is the traditional way of dealing with this problem. While it may prevent flooding of downstream infrastructure, traditional peak flow attenuation does little to prevent stream channel degradation and downstream sedimentation, and may even exacerbate it. There are several reasons for this. Peak flow attenuation is usually applied only to relatively infrequent storms (i.e. 2-yr, 10-yr, 25-yr or greater). This type of detention usually has little or no effect on the exaggerated post-development hydrographs from the smaller, more frequent storms (i.e. 3-month, 6-month and 1-yr) that produce flows high enough to cause significant channel degradation. Also, since peak flow attenuation does not reduce the total volume of runoff, the peak flow is sustained over a much longer timeframe and the stream channel is therefore exposed to highly erosive flows for a longer period than it would have been without the peak attenuation. This is illustrated in Figure 2-2, which shows a typical hydrograph for a developed site where peak attenuation controls are used compared with hydrographs for unde-veloped and uncontrolled developed sites. In fact, when viewed on a watershed-wide basis, studies have shown that peak attenuation alone can sometimes result in an increase in stream peak flows from pre-developed conditions due to a shift in the timing and duration of the peak flows. Peak controls on several different developed sites that before development were staggered, may cause the truncated peaks to overlap, thus increasing the stream flow. Also, detention of the peak from a developed site low in the watershed may cause it to coincide with the peak streamflow from the upper part of the watershed.

To effectively limit the negative impacts of development on stream morphology and habitat, stormwater management systems must do more than the traditional peak flow attenuation of large, infrequent storms. They must minimize exposure of the stream channel to erosive flows either through extended detention of the discharge or through reduction in the volume of the stormwater discharge for the more frequent, potentially channel shaping storms.

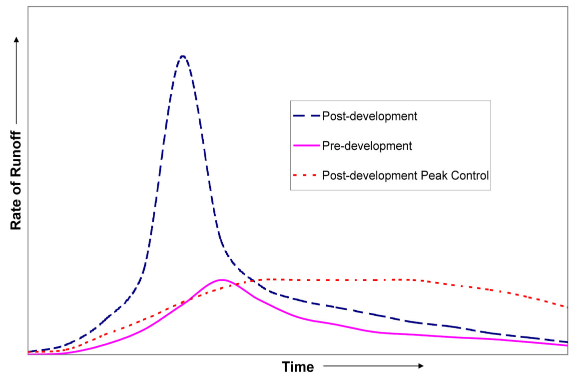


Figure 2-2. Pre and Post Development Hydrographs with Peak Control

Inadequate Pollutant Removal

The principal focus of traditional stormwater management has been avoidance of down-stream flooding, usually involving detention basins that truncate peak flows during large infrequent storms. These detention basins provide little if any pollutant removal because the majority of storm flows pass quickly through with little opportunity for loss of sediment. In Maine, the exception to this has been in lake watersheds where, for several decades, many developers have been required to incorporate measures such as wooded buffers or wet ponds to reduce phosphorus export from the developed site. In most stream and coastal watersheds, the pollutant removal requirements have either been absent or limited to a total suspended solids (TSS) removal requirement that in most situations result in the removal of only coarser, sand-sized particles that are easily removed by short term sedimentation processes. Unfortunately, the majority of nutrients, heavy metals and hydrocarbons in urban stormwater tend to be either dissolved or associated with the finer, silt-sized particles suspended in the stormwater. So, traditional management of stormwater has done little to prevent these pollutants from reaching streams and coastal waters, where they often have harmful effects on the biological communities. These pollutants will be effectively removed and the communities protected only if filtration, infiltration, long term sedimentation and/or biological processes are incorporated in our stormwater management systems

Inadequate Shading

Many of the organisms native to Maine streams cannot tolerate the high summer temperatures common in urban streams. The elevated temperatures are caused by reduced shading in developed riparian areas, warming of stormwater as it runs over hot roofs and pavement, and heating of water stored in stormwater management ponds. Traditional peak reduction outlet structures and simple spillway outlets do nothing to cool the water before discharge. To address this problem, alternative BMPs, such as buffers, infiltration or under-drained filters can be used, or, if ponds are required, under-drained outlet structures can provide effective cooling. Equally important to maintaining cool stream temperature is preservation and/or restoration of riparian trees and shrubs to provide shade.

The natural riparian buffer has been removed from this stream, reducing shade and increasing the temperature of the stream. Many native organisms cannot tolerate these higher temperatures.

Lack of Maintenance

Stormwater treatment units, also known as Best Management Practices or BMPs, can work well as long as they are maintained appropriately. Maintenance is a key criteria that needs to be incorporated into every BMP design and the maintenance burden needs to be as small as possible to ensure success of the BMP. In Maine's cold weather climate, sanding and salting of roads, driveways and parking lots is common practice and significantly increases the sediment loading to BMPs. If BMPs are not sized adequately to hold these sediments and to allow ease of maintenance, the BMP may fail prematurely. As a general rule of thumb, vegetated BMPs should be designed for no more than annual maintenance, or spring and fall. Anything else is likely too demanding for most owners/municipalities.

Additionally, some BMPs such as underground parking lot infiltration units may be designed with a bypass feature in the case of failure. This allows water to pass through the system untreated, without any outside indication that the system is failing. The end result is a greater maintenance burden and cost on the owner or significant water quality impacts, or more likely, both. Instead of a bypass for failure, BMPs should cause flooding or some other indication that they need attention.

Systems need to be designed with realistic maintenance goals (i.e., annual maintenance) and must be easily accessible for inspection and maintenance activities.

These culverts are preceded by a small detention area, which has filled in with sediment due to lack of maintenance. As a result, sediment is transported from this area further downstream during storms events. Improvements to increase the detention area could easily be made, however, periodic maintenance is crucial to the performance of the BMP.

Failures and Replacement

All drainage structures will eventually fail, even if religiously maintained and cared for. Although some types of BMPs, for example detention basins, may not need outright replacement, excavating and disposing of the sediments once it is completely full can be costly and difficult.

Underground parking lot units are particularly susceptible to unseen failure. Because they are not visible and sometimes not even readily accessible, they may quickly fail if not maintained. They are also expensive for the site owner to replace. Without maintenance, most will probably be useless within a few months or a year, with stormwater from the parking lot left to discharge completely untreated. Pretreatment and maintenance are essential to extend the life of a BMP.

Subsurface detention and infiltration galleries, where feasible, like this one have become popular in recent years due to their space saving location under the parking lot. With visible and adequate pretreatment and frequent maintenance, they can work well and will help recharge groundwater. However, many designs today do not have pretreatment and are difficult to clean out, so they quickly fill with sand and fail. The pollutants they were supposed to treat then go out to water bodies or into the municipal system where taxpayers foot the bill for maintenance.

2.2 The Four Stormwater Management Objectives

The department has reviewed past stormwater management requirements and practices and has identified the following objectives as necessary for most stormwater management systems: effective pollutant removal, cooling, channel protection and flood control. These objectives may be met either directly by providing BMPs that manage and treat the runoff after it has been created, or indirectly by incorporating low impact development site planning concepts to minimize production and contamination of runoff by maximizing infiltration and evapotranspiration.

Traditional wet ponds like this one collect heated runoff from paved surfaces and allow it to heat up further in the hot sun before being discharged to a nearby stream. The incorporation of a principal spillway that discharges through an under-drained gravel trench will provide adequate cooling of the stormwater before discharging and slower release of stormwater, while offering better pollutant removal efficiencies. The pond can also be designed to control peak flows, meeting all four of Maine DEP's objectives.

Effective Pollutant Removal
In order to deliver effective pollutant removal stormwater management systems should provide the following:

- Site planning and operation that minimizes contamination of stormwater;
- Stormwater treatment BMPs that effectively remove the fine particles that carry much of the nutrient and heavy metal load;
- Stormwater treatment BMPs that remove dissolved pollutants (phosphorus and metals); and
- Stormwater treatment BMPs that remove hydrocarbons.

Since all surface waters are vulnerable to the potential harmful effects of stormwater pollution, and most are vulnerable to sedimentation, effective pollutant removal is necessary everywhere, regardless of the receiving water.

Cooling
Unless the receiving water is a lake, major river or tidal water, stormwater management systems should either incorporate strategies to avoid heating of the stormwater or to effectively cool it down (22°C or cooler). These systems should incorporate the following:

- Site planning and operation that minimizes impervious areas, maximizes shading, and minimizes ponding;
- BMP systems that provide some cooling of runoff from hot pavement and roofs; and
- Pond principal spillways that discharge through under-drained gravel trenches or provide for some other means of cooling.

Channel Protection

Unless the receiving water is a lake, major river or tidal water, stormwater management systems should either incorporate strategies that minimize the magnitude and duration of enhanced stormwater discharge from the site to avoid destabilization and resulting sedimentation of receiving stream channels. These systems should incorporate the following:

- Site planning and operation that minimizes the volume and rate of discharge of stormwater by minimizing impervious area, maximizing infiltration and evapotranspiration, and maximizing time of concentration of storm flows; and

- BMP systems that provide storage and slow release of not only the very large, infrequent storms, but, more importantly, the relatively frequent moderate sized storms that happen several times each year and have the potential to cause significant stream channel erosion and destabilization.

Flood Control

For some projects, the traditional flood control detention for very large, infrequent storms will still be necessary to avoid flooding of downstream infrastructure. Such control is generally unnecessary when projects discharge directly to large bodies of water such as lakes, major rivers or tidal waters. It also may be unnecessary, and actually harmful, in developments near the bottom of a stream's watershed where detention to control peak flow may hold up the peak long enough so that it can coincide with the peak from the upper watershed, thus exacerbating rather than avoiding flooding. There is no existing rule of thumb or easy answer to evaluate whether an individual flood control project will help or hurt the downstream flooding situation. A comprehensive analysis of the contributing watershed and the detention structures contained within would be the most accurate analysis of downstream impacts, but requires a significant amount of information to generate.

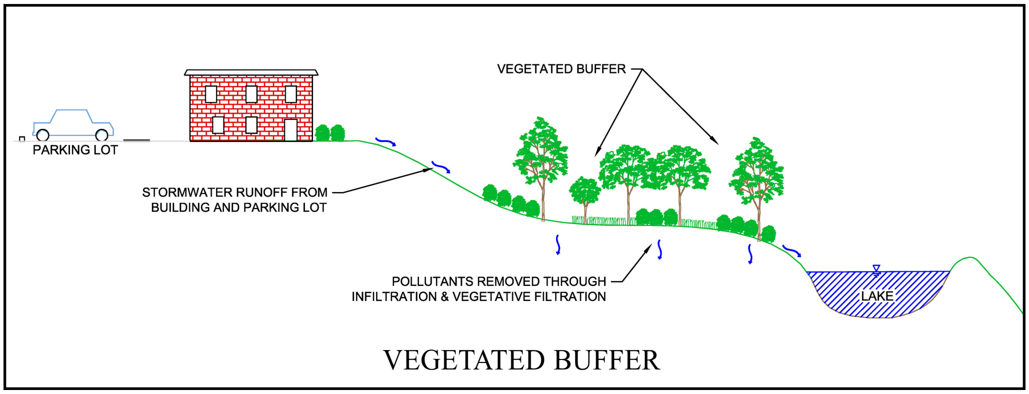
2.3 BMPs to Achieve Objectives

DEP is recommending four types of BMPs that if sized appropriately, will provide effective pollutant removal, cooling and channel protection. In some instances they may also provide flood control benefits without the need for a pond structure. A brief introduction to these BMP types is provided below, with details on their application and construction provided in Volume III. An alternative stormwater management system may be used if it will provide equivalent pollutant removal, cooling and channel protection.

Vegetated Buffers

Vegetated buffers consist of natural or planted strips of vegetation (non-lawn) located adjacent to and downgradient from a developed tract of land. They provide protection by allowing pollutants to filter out of stormwater runoff as it travels across the buffer and through the vegetation. Buffers are typically used to treat runoff from smaller developments and require minimal maintenance. DEP has established acceptable buffer lengths for various applications to meet the objectives previously outlined. Four types of buffers are included in DEP's regulation:

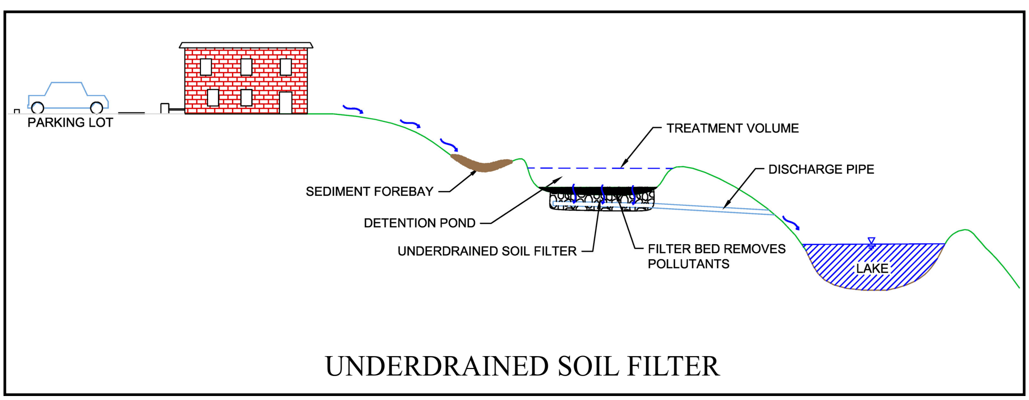
- Vegetated buffer with stone bermed level lip spreaders – this is for areas where stormwater flows may be concentrated and a level lip spreader is needed to uniformly distribute flows.
- Buffer adjacent to the down hill side of a road – this is to treat sheet runoff from a road and shoulder.
- Ditch turn-out buffer – this is to treat runoff collected in a ditch along the side of a road and use level lip spreaders to evenly disperse the runoff into the buffer.



Vegetated buffers remove pollutants through filtration as the stormwater runoff travels across the buffer and through the vegetation. The vegetative canopy also helps to cool the stormwater runoff and contributes to the natural cycle of evapotranspiration, minimizing the amount of stormwater runoff reaching the stream or lake. Buffers also provide for some infiltration due to the natural depressions found across the buffer, which allow some minor ponding to occur.

Underdrained Soil Media Filters

Underdrained soil filters consist of a loamy, coarse sand mix underlain by a gravel bedding and perforated pipe. Stormwater runoff is collected in a storage area above the soil filter, where the runoff passes through the soil and discharges through the underdrain piping. The soil media filters out particles and pollutants that bind to the soils, while also cooling the stormwater runoff. Underdrained soil filters are typically incorporated into a detention structure, or a proprietary filter system approved by the department may be used.

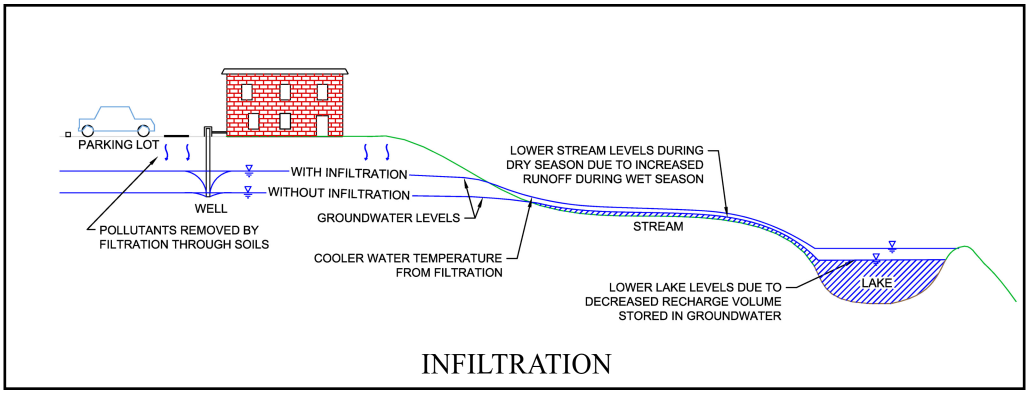


An underdrain soil filter works by discharging water through a constructed soil media, which is underlain by a perforated drainage pipe. The stormwater runoff is filtered through the soil providing cleaner, cooler water which is then collected into a drainage pipe and discharged to a nearby receiving water. The soil media can also act to absorb and release water through evapotranspiration when combined with vegetation. When combined with a detention basin, this BMP can be used to meet all four of DEP's objectives.

Infiltration

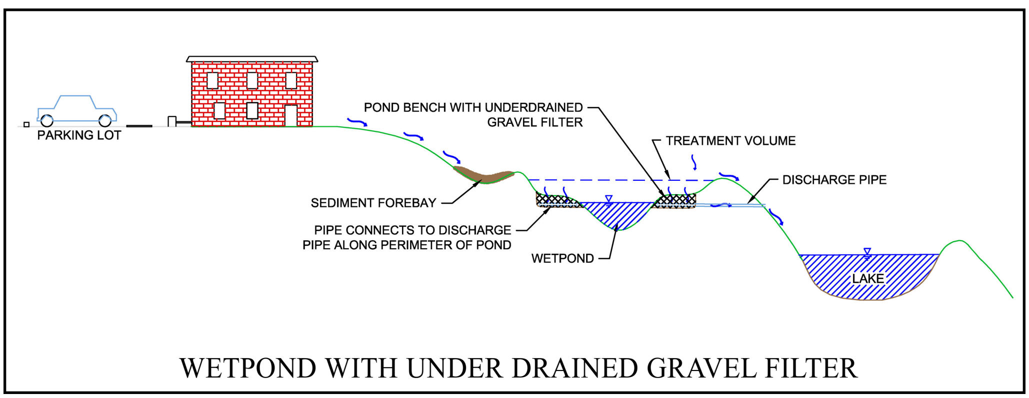
Infiltration involves discharging stormwater runoff into the ground. The runoff percolates through soils, which act as a filter to cleanse the stormwater before discharging it to the groundwater table. In addition to meeting DEP's objectives, infiltration also minimizes the volume of water reaching surface waters as runoff and increases stream baseflows.

It is critical that adequate pretreatment be provided prior to discharge to an infiltration area to prevent the system from clogging.



Infiltration involves discharging stormwater runoff into the ground. The stormwater is filtered through natural soils, removing pollutants, before it reaches groundwater. It has many benefits including: cooler water temperatures reaching lakes and streams due to filtration through soils; higher groundwater levels for water supplies; higher summer stream levels; and cleaner water. It can also reduce flooding issues by imitating natural, pre-developed conditions.

Wet Pond with Underdrained Gravel Filter
A wet pond consists of a detention structure with a permanent pool. The stormwater runoff is detained above the permanent pool and discharged through an underdrained vegetated gravel filter. The gravel filters are built on an elevated pond bench, set above the permanent pool and running the length of the pond. The gravel media filters out particles and pollutants that bind to the gravel, while also cooling the stormwater runoff. The treated stormwater discharges through a perforated pipe located beneath the gravel filter.



A traditional wetpond consists of a permanent pool with detention storage above the pool for stormwater runoff. Although wetponds can be beneficial in removing pollutants from stormwater, the pool itself heats up in the warm summer sun, discharging warm water to lakes and streams. A modification to the traditional design, incorporating an underdrained gravel filter forces the stormwater runoff to filtrate through the gravel filter to a perforated discharge pipe located at the bottom of the filter. This helps to remove the finer particles in the stormwater and cools the stormwater before it is discharged. The wetpond can also be sized to handle peak discharge, meeting all four of DEP's objectives.

References
Comprehensive Environmental Inc. March 2003. *City of Nashua, New Hampshire Alternative Stormwater Management Methods, Part 1 – Planning & Guidance.*